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National and Global Petroleum Assessment

Assessment of Undiscovered Conventional Oil and Gas Resources of the West Greenland-East Canada Province, 2023

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean conventional resources of 7.8 billion barrels of oil and 91.9 trillion cubic feet of gas in the West Greenland-East Canada Province.

Introduction

The U.S. Geological Survey (USGS) assessed the potential for undiscovered, technically recoverable conventional oil and gas resources in the West Greenland-East Canada Province as part of the ongoing assessment of conventional resources in priority provinces of the world (fig. 1). The assessment includes an allocation of undiscovered conventional resources within this province to the area north of the Arctic Circle. The West Greenland-East Canada Province has a complex tectonic evolution involving multiple phases of extension, thermal subsidence, movement along regional transform and strike-slip fault systems, changes in direction of plate movement, volcanism, and uplift and erosion (Funck and others, 2012; Oakey and Chalmers, 2012; Gregersen and others, 2013; McGregor and others, 2014; Peace and others, 2018; Jauer and others, 2019; Knutz and others, 2022). The initial phase of rifting is generally interpreted to have begun in the Early Cretaceous (Valanginian–Hauterivian) as Greenland began to diverge from North America (Dam and Sønderholm, 2021), but rifting may have begun prior to the Early Cretaceous (Larsen and others, 2009; Jess and others, 2018; Peace and others, 2018). After a phase of thermal subsidence in the Late Cretaceous (Cenomanian–Santonian) during which potential organic-rich Cenomanian source rocks may have been deposited, rifting was renewed in the Campanian and ceased in the Paleogene as seafloor spreading heralded the opening of the Labrador Sea and Baffin Bay, which were linked by the Ungava transform fault zone. By the Eocene, the east–northeast movement of Greenland evolved to a more northward direction as eastern Greenland began to separate from Eurasia and Greenland rotated counterclockwise (Gregersen and others, 2013; Jess and others, 2018). Northward movement of Greenland resulted in contractional deformation of the Eurekan orogeny in northern Greenland and Ellesmere Island and caused a more northward orientation of the strike-slip Ungava fault zone and Hudson fracture zone, causing transtension, pull-apart basins, flower structures, uplift and erosion of rift shoulders, and inversion of existing structures (Dam and Sønderholm, 2021). Seafloor spreading in the Labrador Sea and Baffin Bay ended in the late Eocene with Greenland attached to North America, while eastern Greenland continued to separate from Eurasia. From the late Eocene to the present, the conjugate margins of eastern Canada and western Greenland have remained passive, but both margins were subjected to several phases of uplift, erosion, and volcanism (Gregersen and others, 2013; Jess and others, 2018) that may have resulted in remigration or loss of oil and gas.

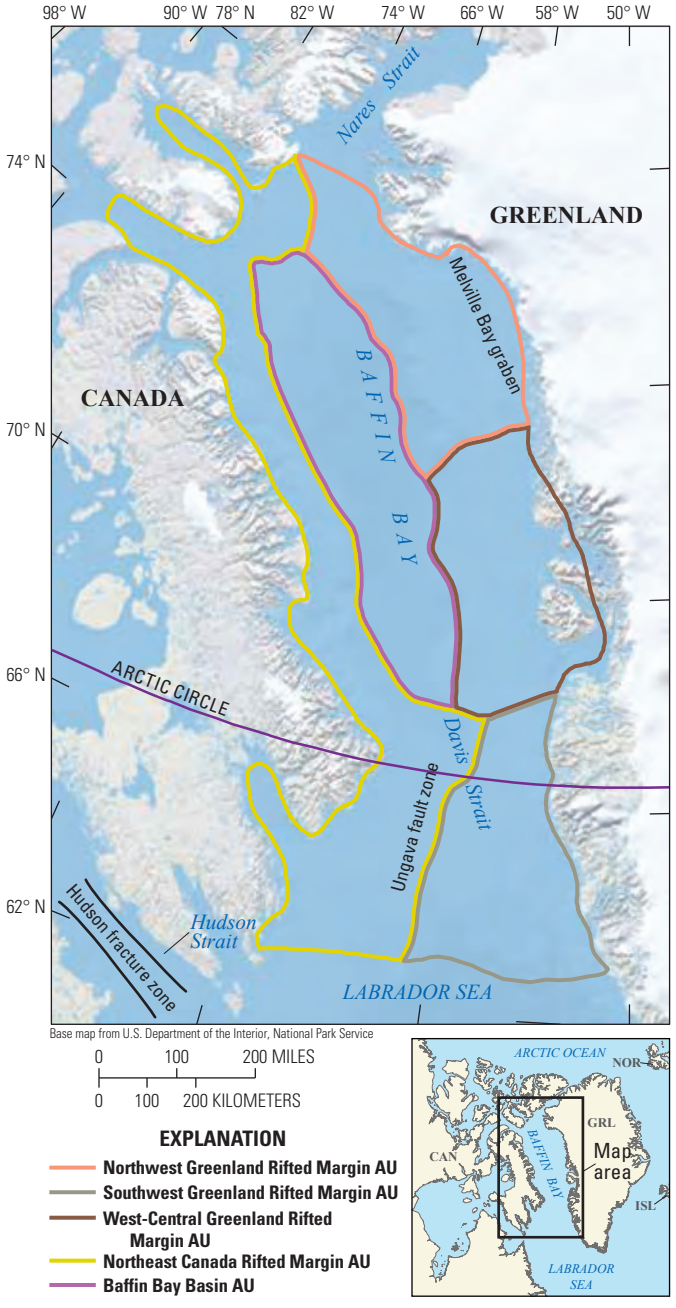

Figure 1. Maps showing the location of five conventional assessment units (AUs) in the West Greenland-East Canada Province.

Total Petroleum System and Assessment Units

The USGS defined the Mesozoic–Cenozoic Composite Total Petroleum System (TPS) in the West Greenland-East Canada Province (Schenk, 2011), which consists of potential hydrocarbon source rocks of Albian, Cenomanian–Turonian, Campanian, Paleocene–Eocene, and Miocene age (Bojesen-Koefoed and others, 1999; Christiansen and Bojesen-Koefoed, 2021) that may be present within both the western Greenland and eastern Canada rifted margins (Dam and others, 2020a). Within the TPS, five assessment units (AUs) were redefined from those of 2011 (Schenk, 2011) based on a compilation of new and existing information on the TPS elements of the western Greenland margin, the eastern Canada margin, and Baffin Bay (Harrison and others, 2011; Dam and others, 2020a, b; Dam and others, 2021; Dam and Sønderholm, 2021). The Geological Survey of Denmark and Greenland defined the Northwest Greenland Rifted Margin AU, Southwest Greenland Rifted Margin AU, and West-Central Greenland Rifted Margin AU (Dam and others, 2020a, b; Dam and others, 2021), and these three AUs were adopted for this assessment. The Northeast Canada Rifted Margin AU and the Baffin Bay Basin AU were defined in the compilation of geologic information by Harrison and others (2011) and were also adopted for this assessment (fig. 1).

Several hydrocarbon source rocks have been interpreted within the Mesozoic–Cenozoic Composite TPS based mainly on the geochemistry of oil seeps from the western Greenland margin (Christiansen and Bojesen-Koefoed, 2021). Peace and others (2018) suggested that Cretaceous source rocks may be spatially limited within grabens and the organic facies may be laterally varied. The potential source rocks within the thermal subsidence intervals may be more widespread, such as organic-rich Cenomanian mudstones. Modeling has indicated that several source rocks have reached the thermal generation windows for oil and gas (McGregor and others, (2014), and the deeper basins, such as the Melville Bay graben, may have several sources within the thermal gas generation window. Regionally, thermal maturation for oil and gas generation is modeled as occurring from the Eocene to the Miocene (McGregor and others, 2014).

Potential oil and gas reservoirs in the TPS have been summarized by Dam and Sønderholm (2021) as synrift and postrift. Reservoirs related to the first phase of rifting include alluvial fan to fluvial and deltaic channel sandstones, nearshore to deepwater lacustrine sandstones, and estuarine to marginal-marine sandstones. Reservoirs in the thermal subsidence phase are fluvial-deltaic channel sandstones, nearshore to shelf sandstones, and slope-channel to deep submarine fan sandstones. Reservoirs in the second rift phase are fluvial-deltaic channel sandstones to slope-channel and deep marine fan sandstones. Incised valleys have stacked fluvial and estuarine channel sandstones. Postrift reservoirs range from fluvial-deltaic to nearshore marine sandstones. Fractured volcanic rock may also form potential oil and gas reservoirs. Traps are complex along both margins because several phases of rifting, strike-slip faulting, and contractional deformation have modified original structures. Regional uplift and erosion related to mantle plumes may have resulted in loss of oil or gas. The assessment input data for five conventional AUs are summarized in table 1 and in Schenk (2025).

Table 1. Key input data for five conventional assessment units in the West Greenland-East Canada Province.

[Gray shading indicates not applicable. AU, assessment unit; MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

Assessment input data—Conventional AUs	Northwest Greenland Rifted Margin AU				Southwest Greenland Rifted Margin AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	20	80	22.1	1	20	80	22.1
Number of gas fields	1	60	240	66.2	1	60	240	66.2
Size of oil fields (MMBO)	5	8	10,000	68.9	5	8	5,000	45.4
Size of gas fields (BCFG)	30	48	50,000	369.2	30	48	30,000	272.6
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**West-Central Greenland Rifted Margin AU**				**Northeast Canada Rifted Margin AU**			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	20	80	22.1	1	50	300	58.9
Number of gas fields	1	60	240	66.2	1	50	300	58.9
Size of oil fields (MMBO)	5	8	5,000	45.4	5	8	5,000	45.4
Size of gas fields (BCFG)	30	48	30,000	272.6	30	48	30,000	272.6
AU probability	1.0				1.0			
Assessment input data—Conventional AUs	**Baffin Bay Basin AU**			
	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	30	180	35.3
Number of gas fields	1	30	180	35.3
Size of oil fields (MMBO)	5	8	5,000	45.4
Size of gas fields (BCFG)	30	48	30,000	272.6
AU probability	1.0			

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered conventional oil and gas resources in five AUs in the West Greenland-East Canada Province (table 2). The estimated mean resources are 7,769 million barrels of oil (MMBO), or 7.8 billion barrels of oil, with an F95–F5 range from 1,131 to 23,185 MMBO; 91,897 billion cubic feet of gas (BCFG), or 91.9 trillion cubic feet of gas, with an F95–F5 range from 18,018 to 236,136 BCFG; and 1,896 million barrels of natural gas liquids (MMBNGL), or 1.9 billion barrels, with an F95–F5 range from 368 to 4,885 MMBNGL. For the part of undiscovered resources north of the Arctic Circle in the West Greenland-East Canada Province, the allocated mean resources are 5,950 MMBO, or 6 billion barrels of oil, with an F95–F5 range from 839 to 18,001 MMBO; 69,632 BCFG, or 69.6 trillion cubic feet of gas, with an F95–F5 range from 13,331 to 180,875 BCFG; and 1,450 MMBNGL, or 1.4 billion barrels, with an F95–F5 range from 273 to 3,781 MMBNGL.

Table 2. Results for five conventional assessment units in the West Greenland-East Canada Province, and an allocation of undiscovered resources north of the Arctic Circle.

[Results shown are fully risked estimates. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Gray shading indicates not applicable. MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids]

Total petroleum system and assessment units (AUs)	AU probability	Accumulation type	Total undiscovered resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Mesozoic–Cenozoic Composite Total Petroleum System														
Northwest Greenland Rifted Margin AU	1.0	Oil	168	874	5,244	1,514	109	568	3,409	984	2	11	68	20
		Gas					4,889	19,115	62,089	24,498	98	382	1,239	490
Southwest Greenland Rifted Margin AU	1.0	Oil	152	655	3,089	994	99	426	2,010	646	2	9	40	13
		Gas					4,183	14,647	43,052	18,035	84	293	860	361
West-Central Greenland Rifted Margin AU	1.0	Oil	151	660	3,095	1,001	98	429	2,006	650	2	9	40	13
		Gas					4,153	14,684	43,169	18,006	83	294	862	360
Northeast Canada Rifted Margin AU	1.0	Oil	442	2,021	6,997	2,660	286	1,312	4,557	1,729	6	26	91	35
		Gas					2,659	12,116	42,495	16,035	53	242	850	321
Baffin Bay Basin AU	1.0	Oil	218	1,104	4,760	1,600	216	1,102	4,752	1,600	5	28	119	40
		Gas					1,326	6,735	28,597	9,714	33	168	716	243
Total undiscovered conventional resources			**1,131**	**5,314**	**23,185**	**7,769**	**18,018**	**71,134**	**236,136**	**91,897**	**368**	**1,462**	**4,885**	**1,896**
Conventional resources north of the Arctic Circle														
Northwest Greenland Rifted Margin AU	1.0	Oil	168	874	5,244	1,514	109	568	3,409	984	2	11	68	20
		Gas					4,889	19,115	62,089	24,498	98	382	1,239	490
Southwest Greenland Rifted Margin AU	1.0	Oil	24	105	494	159	16	68	322	103	0	1	6	2
		Gas					669	2,344	6,888	2,886	13	47	138	58
West-Central Greenland Rifted Margin AU	1.0	Oil	151	660	3,095	1,001	98	429	2,006	650	2	9	40	13
		Gas					4,153	14,684	43,169	18,006	83	294	862	360
Northeast Canada Rifted Margin AU	1.0	Oil	278	1,273	4,408	1,676	180	827	2,871	1,089	4	17	58	22
		Gas					1,675	7,633	26,772	10,102	33	152	535	202
Baffin Bay Basin AU	1.0	Oil	218	1,104	4,760	1,600	216	1,102	4,752	1,600	5	28	119	40
		Gas					1,326	6,735	28,597	9,714	33	168	716	243
Total undiscovered conventional resources north of the Arctic Circle			**839**	**4,016**	**18,001**	**5,950**	**13,331**	**53,505**	**180,875**	**69,632**	**273**	**1,109**	**3,781**	**1,450**

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For More Information

Assessment results are also available at the USGS Energy Resources Program website, https://www.usgs.gov/programs/energy-resources-program.

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